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Percolation properties of complex networks with weak and strong clustering

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A diversity of systems in the real world can be analyzed as complex networks. This makes any theoretical development in the field potentially applicable to many different areas. As a germane example, percolation has helped us to understand, for instance, the high resilience of scale-free networks in front of the random removal of a fraction of their constituents, with important implications for communication or biological systems among others. In addition to its high theoretical interest, it serves as a conceptual approach to treat more factual problems on networks, such as the dynamics of epidemic spreading. On the other hand, when large systems of interactions are mapped into comprehensible graphs, just vertices and edges are usually recognized as the primary building blocks. However, transitive relations, represented by triangles and referred to as clustering, should also be taken into account as a basic structure whose presence and self-organization can drastically impact network structure and properties. In this framework, the introduction of clustering in the percolation analysis of complex networks represents a theoretical challenge. Previous approaches were based on the idea of branching process, which works well when the network is locally treelike and thus the clustering coefficient is very small. Real networks, however, are shown to have a significant level of clustering. They can be classified in networks with weak transitivity, in which triangles are disjoint, and networks with strong transitivity, where edges are forced to share many triangles. The class a network belongs to changes its percolation properties. For networks with weak clustering, we find analytically the critical point for the onset of the giant component and its size. By means of numerical simulations, we also prove that, when comparing with the unclustered counterpart, weak clustering hinders the onset of the giant connected component whereas it is favored by strong clustering. This is a direct consequence of the differences in the k-core structure for the two types of networks. In the particular case of scale-free networks, and although clustering can strongly affect the size and the resilience of the giant connected component, neither weak nor strong transitivity can restore a finite percolation threshold which, in turn, implies the absence of an epidemic threshold.